AD-A278 402

MENTATION PAGE

Form Approved
OMB No. 0704-0188

REPORT DATE	3. REPORT TYPE AND DATES COVERED
	FINAL/01 JUL 92 TO 30 SEP 93

4. TITLE AND SUBTITLE
HOW HINTS AFFECT LEARNING (U)

5. FUNDING NUMBERS
2304/HS
F49620-92-J-0398

6. AUTHOR(S)
Professor Yaser Abu-Mostafa

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Mail Stop 116-81
California Institute of Technology
Pasadena, CA 91125

8. PERFORMING ORGANIZATION REPORT NUMBER
AFOSR-TR- 94 0196

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR/NM
110 DUNCAN AVE, SUITE B115
BOLLING AFB DC 20332-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
F49620-92-J-0398

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE
UL

13. ABSTRACT *(Maximum 200 words)*

The use of hints as an aid in learning from examples is addressed. Hints describe the situation where, in addition to the set of examples of some unknown function f (that we are trying to learn), we have prior knowledge of certain facts about f. The use of hints, under different names is coming to the surface in a number of areas dealing with learning and adaptive systems. The most common complaint is that hints are heterogeneous and cannot easily be integrated into learning. The final report describes the development of a systematic method that integrates different types of hints in the same learning process. Algorithms for learning from hints are presented. These algorithms use fixed or adaptive schedules to determine the turn of each hint to be learned in order to achieve balance among the errors of different hints. Also, a theoretical analysis of learning from hints is developed. It is based on the Vapnik-Chervonekis (VC) dimension, which is an established tool for analyzing learning from examples.

14. SUBJECT TERMS
DTIC QUALITY INSPECTED 3

15. NUMBER OF PAGES
33

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR(SAME AS REPORT)

FINAL REPORT

HOW HINTS AFFECT LEARNING

AFOSR Grant Number F49620-92-J-0398

PI: Prof. Y. S. Abu-Mostafa, Caltech
PM: Capt. S. Suddarth, AFOSR

C O N T E N T S

Learning from Hints

1. INTRODUCTION

It is evident that learning from examples needs all the help it can get. When an unknown function f is represented to us merely by a set of examples, we are faced with a dilemma. We would like to use a model that is sophisticated enough to have a chance of simulating the unknown function, yet we want the model to be simple enough that a limited set of examples will suffice to 'tune' it properly. These two goals are often on a collision course.

One established method of tackling this problem is regularization (Akaike, 1969). It is an attempt to start out with a sophisticated model and then restrict it during the learning process to fit the limited number of examples we have. Thus we have a simple model in disguise, and we make it as simple as warranted by the resources. The hope is that the restriction (simplification) of the model has not rendered f impossible to simulate, and the justification is that this is the best we can do anyway given a limited set of examples.

Another method for tackling the problem is the use of hints (Abu-Mostafa, 1990,1993) as a learning aid. Hints describe the situation where, in addition to the set of examples of f, we have prior knowledge of certain facts about f. We wish to use this side information to our advantage. However, hints come in different shapes, and the main difficulty of using them is the lack of a systematic way of incorporating heterogeneous pieces of information into a manageable learning process. If what we know about f is that it is scale-invariant, monotonic over part of its domain, and represented by a given set of examples, we still have to integrate this information before we can learn the function. This paper concerns itself with the development of a systematic method that integrates different types of hints in the same learning process.

The distinction between regularization and the use of hints is worth noting. Regularization restricts the model in a way that is not based on known facts about f. Therefore, f may be implementable by the original model, but not by the restricted model. In the case of hints, if the unrestricted model was able to implement f, so would the model restricted by the hints, since f cannot be excluded by a litmus test that it is known to satisfy. We can apply any number of hints to restrict the model without risking the exclusion of f. The use of hints does not preclude, nor does it require, the use of any form of regularization.